MCB 413

FACTORS AFFECTING GROWTH OF MICROORGANISMS IN FOOD

INTRINSIC FACTORS

1. pH:

- microorganisms grow best at pH values around 7.0 (6.6–7.5)
- whereas few grow below 4.0
- most of the meats and seafoods have a final pH of about
- 5.6 and above thus they are susceptible to bacteria as well as to mold and yeast spoilage.

- Fruits should have pH values below those required by many spoilage organisms.
- Acidic pH values are of greater use in inhibiting microorganisms.
- Alkaline values ranging from pH 12–13 are known to be destructive, at least to some bacteria.
- Use of $CaOH_2$ produces pH values in this range has been shown to be destructive to *Listeria monocytogenes* and other foodborne pathogens on some fresh foods.

- pH affects (a) the functioning of microbial enzymes and (b) the transport of nutrients into the cell.
- When microorganisms are placed in environments below or above neutrality, their ability to proliferate depends on their ability to bring the environmental pH to a more optimum value or range.

- When most microorganisms grow in acid media, their metabolic activity causes the medium or substrate becoming less acidic.

- On the other hand, those that grow in high pH environments tend to effect a lowering of pH.

- Amino acid decarboxylases that have optimum activity at around pH 4.0 and almost no activity at pH 5.5.

- This enzyme cause a spontaneous adjustment of pH toward neutrality when cells are grown in the acid range.

- When grown in the alkaline range, a group of amino acid deaminases that have optimum activity at about pH 8.0 and cause the spontaneous adjustment of pH toward neutrality.

- *Enterobacter aerogenes* produces acetoin from pyruvic acid to raise the pH of its growth environment.

- *Clostridium acetobutylicum* raise the substrate pH by reducing butyric acid to butanol

Moisture Content

- Foods can be preserved by drying which is a direct consequence of removal or binding of moisture, without which microorganisms do not grow.
- Water requirements of microorganisms should be described in terms of the *water activity* (a_w) in the environment.
- Water vapor pressure of food substrate to the vapor pressure of pure water at the same temperature:

  $a_w = p/p$

  where p is the vapor pressure of the solution and p_o is the vapor pressure of the solvent (usually water).

- Pure water has an a_w of 1.00.
- 22% NaCl solution (w/v) has a_w of 0.86,
- A saturated solution of NaCl has an a_w of 0.75
- The water activity (aw) of most fresh foods is above 0.99.
- Generally, bacteria require higher values of a_w for growth than fungi
- Also, Gram-negative bacteria have higher a_w demands than Gram positives.
- Most spoilage bacteria do not grow below a_w = 0.91, but spoilage molds can grow as low as 0.80.

- Foodborne halophilic bacteria can have a_w of 0.75
- Xerophilic mold have a_w of 0.65
- Osmophilic yeast can have as low as 0.61
- When a_w is below optimum the length of the lag phase of growth is increased and growth rate and size of final population are decreased.
- When large quantity of salt or sugar are added to food, most microbes become dehydrated by the hypertonic conditions that result and cannot grow.

Oxidation–Reduction Potential

- The oxidation and reduction potential of a substrate may be defined generally as the ease with which the substrate loses or gains electrons.

- When an element or compound loses electrons, the substrate is oxidized, whereas a substrate that gains electrons becomes reduced.

- When electrons are transferred from one compound to another, a potential difference is created between the two compounds.
- This difference expressed as millivolts (mV).
- The more highly oxidized a substance, the more positive will be its electrical potential; the more highly reduced a substance, the more negative will be its electrical potential.

- The O/R potential of a system is expressed by the symbol Eh.
- Aerobic microorganisms require positive Eh values (oxidized) for growth, whereas anaerobes require negative Eh values (reduced).
- Some bacteria require reduced conditions for growth initiation (Eh of about −200 mV) such as *Clostridium*, whereas others require a positive Eh for growth e.g. *Bacillus*

- Some aerobic bacteria actually grow better under slightly reduced conditions (*microaerophiles)* such as lactobacilli and campylobacters.
- Some bacteria have the capacity to grow under either aerobic or anaerobic conditions (*facultative anaerobes)*.
- Most molds and yeasts encountered in and on foods are aerobic, although a few tend to be facultative anaerobes.

- Plant foods, especially plant juices, tend to have Eh values of from +300 to 400 mV. Thus aerobic bacteria and molds are the commonly cause spoilage such of products.
- Solid meats have Eh values of around –200 mV; in minced meats, the Eh is generally around 200 mV. Cheeses of various types have been reported to have Eh values on the negative side, from –20 to around –200 mV.

- Aerobes can lower the Eh of their environment while anaerobes cannot. As aerobes grow, O2 in the medium is depleted, resulting in the lowering of Eh.

- Eh of a medium can be reduced by microorganisms

by their production of certain metabolic byproducts such as H_2S, which has the capacity to lower Eh to −300 mV.

Nutrient Content

- To grow and function normally, the microorganisms of importance in foods require the following:

1. water
2. source of energy: sugars, alcohols, and amino acids.
3. source of nitrogen: amino acids
4. vitamins and related growth factors
5. minerals

- growth of anaerobes is normally believed to occur at reduced values of Eh, the exclusion
- of O2 may be necessary for some anaerobes. When *Clostridium perfringens*, *Bacteroides fragilis*, and
- *Peptococcus magnus* were cultured in the presence of O2, inhibition of growth occurred even when
- the medium was at a negative Eh of –50 mV.52 These investigators found that growth occurred in
- media with an Eh as high as 325 mV when no O2 was present.

- molds have the lowest requirement followed by Gram-negative bacteria, yeasts, and Gram-positive bacteria in terms of nutrient content apart from water.
- Simple compounds such as amino acids will be utilized by almost all organisms before any attack is made on the more complex compounds such as high-molecular-weight proteins. The same is true of polysaccharides and fats.

- Microorganisms may require B vitamins in low quantities, and almost all natural foods have an abundant quantity for those organisms that are unable to synthesize their essential requirements.

- In general, Gram-positive bacteria are the least synthetic and must therefore be supplied with one or more of these compounds before they will grow.

- The Gram-negative bacteria and molds are able to synthesize most or all of their requirements. Hence their presence in food low in B vitamins.

- Fruits tend to be lower in B vitamins than meats.

Difference in Spoilage Processes in Relation to Food Characteristics

SUBSTRATE	FOOD EXAMPLE	CHEMICAL REACTION	TYPICAL PRODUCT & EFFECTS
Pectin	Fruits	Pectinolysis	Methanol, uronic acids (loss of fruit structure, soft rot)
Protein	Meat	Preteolysis, deamination	Amino acids, peptides, amines, H_2S, ammonia, indole (bitterness, souring, bad odor, sliminess)
Carbohydrates	Starchy food	Hydrolysis, fermentation	Organic acids, CO2, mixed alcohols (souring, acidfication)

Antimicrobial Constituents

- The presence of certain naturally occurring substances that possess and express antimicrobial activity aids the stability of such food.
- Plants such as plant species are known to contain essential oils that possess antimicrobial activity.
- Examples include: eugenol in cloves, allicin in garlic, cinnamic aldehyde and eugenol in cinnamon, allyl isothiocyanate in mustard.

- Milk casein as well as some free fatty acids have been shown to be antimicrobial under certain conditions.
- Eggs contain lysozyme, as does milk, and this enzyme, along with conalbumin, provides fresh eggs with a fairly efficient antimicrobial system.
- *p*-coumaric, ferulic, caffeic, and chlorogenic acids found in fruits, vegetables, tea, molasses, and other plant sources all show antibacterial and some antifungal activity.

- Ovotransferrin appears to be the inhibitory substance in raw egg white that inhibits *Salmonella enteritidis*.
- Unfermented green and black teas also have polyphenol content that confer antimicrobial properties on them.

Biological Structures

- The natural covering of some foods provides excellent protection against the entry and subsequent damage by spoilage organisms.
- These include testa of seeds, the outer covering of fruits, the shell of nuts, the hide of animals, and the shells of eggs. Eg. Walnut, eggs, fruits and vegetebles
- Skin covering of fish and meats such as beef and pork prevents the contamination and spoilage of these foods, partly because it tends to dry out faster than freshly cut surfaces.